PHYSICS U3 IMPORTANT QUESTIONS

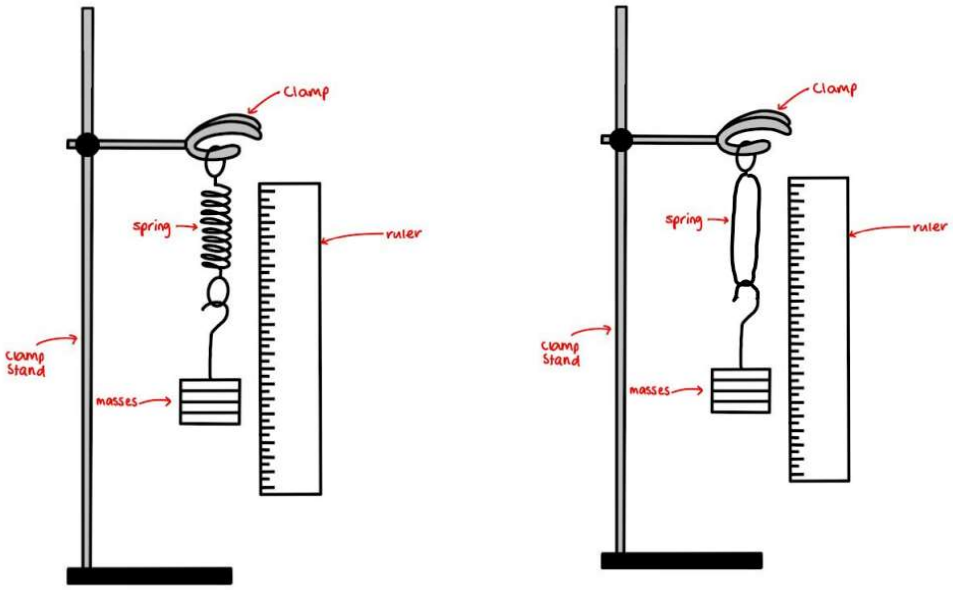
- **Two variables are directly proportional to one another when the line of best fit is passing through the origin and is a straight line**

1. Monochromatic light has a **single wavelength/frequency** Or
2. White light is a **mixture/range of wavelengths/frequencies**
3. The **different wavelengths/colours would refract by different angles and** would have **different refractive indexes**
4. **Monochromatic light would give less uncertainty in the angle (incident/refraction/critical) Or monochromatic light allows for a more accurate measurement of angle**

For a collimator

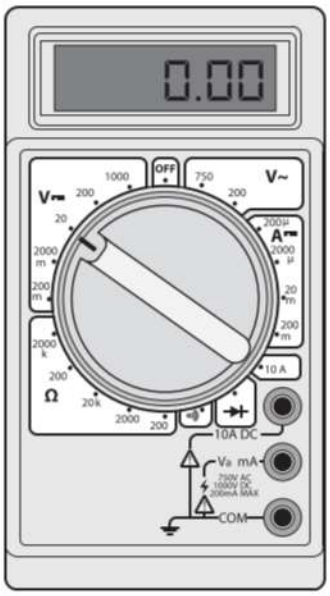
Angle resolution of 0.1˚ compared to protractor resolution of 1˚
Beam from the collimator is narrower (than the ray from a ray box)
So, uncertainty in **angle (of refraction)** is **smaller**

Experiment to plot a graph of force against extension graph for a spring/ rubber band

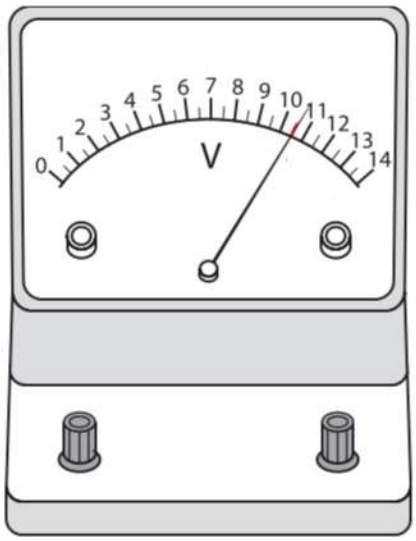


1. **Force applied to band (e.g. slotted masses hanging on free end)**
2. Measure initial length using a ruler

3. Measure **new length**/position and calculate extension
4. Additional detail to improve accuracy e.g. method for **reducing parallax** Or **additional detail to improve safety e.g. ensure feet are not under the masses in case they fall**
   MP2-5 could be awarded for information shown on the diagram (e.g. **metre rule and set squares seen on the diagram**). Allow MP3 and 4 for set-up where **0 on metre rule is aligned with end of band before masses are added, to measure extension directly**



digital multimeter



analogue voltmeter

Resolution - 0.5

1. **(Percentage) uncertainty will be reduced**
2. The multimeter screen/display will not cause a parallax error
3. The multimeter can measure to a **higher resolution** Or the multimeter resolution can be increased by changing the setting Or the multimeter measures to 2 d.p.
   The digital multimeter will not require **interpolation of val**ues

- The student checks for zero errors before taking readings. Explain another experimental technique the student should use in order to make the investigation as accurate as possible when investigating how the **current varies with potential difference** for a filament lamp

1. Repeat readings and average
2. To **reduce (effect of) random errors/anomalies**
3. **Readings on a digital meter fluctuate**
4. **so take readings of I and V simultaneously.**
5. **Allow time for the temperature to become steady**
6. **As I Or R depend on the temperature of the filament**

- A student is asked to determine the density of glass as accurately as possible. He has been provided with a box of 10 glass **microscope slides.**

(a) state the quantities to be measured

1. length, width, thickness and mass/weight (allow volume if replacing length, width and thickness and clear from later parts that displacement method used. NB will then need measuring cylinder in (b)

(b) list the apparatus required

2. Metre rule or Vernier callipers and micrometer [accept digital calliper in place of Vernier calliper and micrometer] Balance/scales

(c) for two of the quantities listed in (a) explain your choice of measuring instrument For each quantity Instrument Justification, including indication of precision related to expected measurement

3. Metre ruler has a precision of **1mm** and micrometer has a precision of **0.01 mm**

(d) comment on whether repeat readings are appropriate

4. Repeat readings are appropriate to **identify anomalies Or deal with random error** Or deal with variation in named measurement.

(e) suggest how to make the measurement of thickness as accurate as possible,

5. Measure the thickness of all 10 slides together Or **measure thickness in various places (or different slides) and average**
6. **To reduce the percentage uncertainty in the measurement**

(f) explain how the measurements made will be used to determine the density

6. Use of volume = length × width × thickness
7. Use of density = mass/volume

(g) state the main sources of uncertainty and/or systematic error

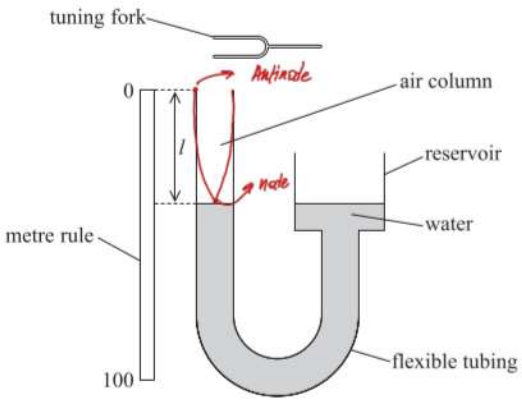
8. Variation of thickness or length or width of slides
9. Thickness is small value
10. Zero error in named instrument
11. Volume incorrect as chip/dust on slide

(h) comment on safety. Hazard and precaution

12. Glass can have **sharp edges or break so handle with care (to avoid injury)**
13. **Don't overtighten micrometer as the glass might break**

- **JAN 2019**

A student determined the speed v of sound using standing waves in an air column.
A diagram of the apparatus is shown.



The student held a vibrating tuning fork above the air column and moved the reservoir up and down to change the length l of the air column. She determined the shortest length at which a sound of maximum loudness was heard. This happens when the standing wave is formed in the air column.

She recorded the length l, as shown in the diagram, using the metre rule.

She repeated this for a number of tuning forks, each marked with a different frequency f.

Her results are shown in the table.

f / Hz	l / m
256	0.322
320	0.25
348	0.228
512	0.160

- Suggest a reason why your calculated value for v may differ from the accepted value for v - when calculating wave speed from a graph of wavelength against 1/frequency

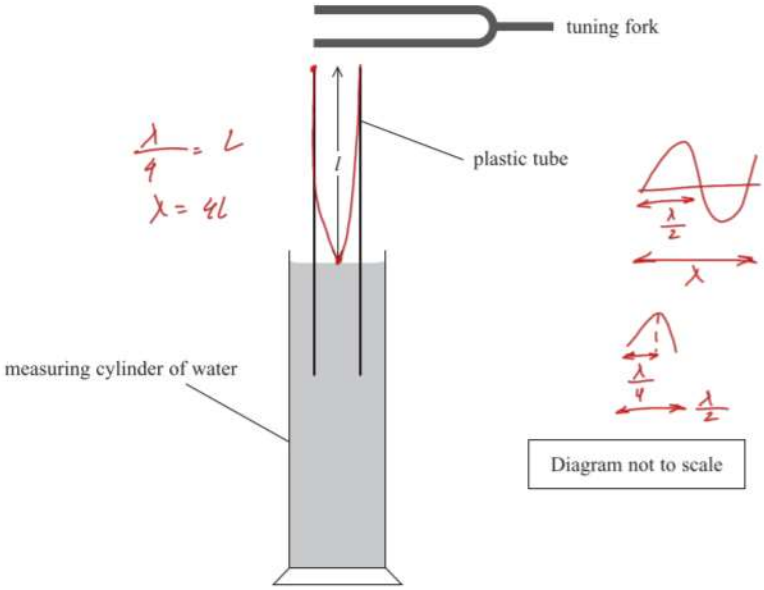
1. **Marked frequency may be incorrect**
2. the **length of the tube may not correspond exactly to λ/4**

3. **Speed of sound in air depends on temperature**
4. **Difficult to locate the exact position for the loudest sound**
5. **Parallax error in measuring length**
6. Poor line of best fit from small number of points

JUNE 2021

2 A student determined the speed of sound in air using a standing wave.

The student used a tuning fork to create a sound wave in the column of air inside a plastic tube. He placed the plastic tube into a measuring cylinder of water so he could adjust the length *l* of the column of air.



The student adjusted *l* until the loudest sound was heard, indicating that a standing wave had formed. He marked the water level on the plastic tube and measured *l*.

He repeated this process several times and recorded the results.

l / cm	18.4	18.0	19.2	19.4	19.2

Suggest two reasons for the variation in the lengths measured by the student

1. Difficult to **identifying when sound was loudest**
2. **Difficulty hearing tuning fork due to background noise**
3. Tube **moved when marking the water level**
4. Tube not **vertical** when water level was marked

JUNE 2019

When measuring the **diameter using vernier calliper**

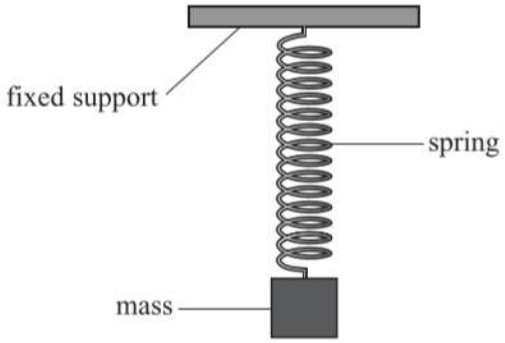
1. Take readings in different orientations and positions
2. Check for zero
3. Ensure measurement is at widest point

Vernier calliper is suitable to measure the diameter of a metal ball sphere

1. As the resolution is 0.1mm, the resolution is smaller than the diameter of the metal ball sphere
2. Percentage uncertainty is small

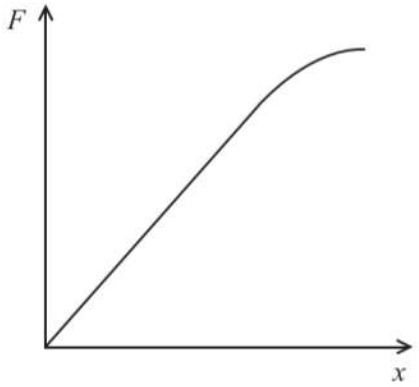
A student investigated the extension of a spring to determine its stiffness.

The student suspended the spring from a fixed support and added masses to the lower end of the spring as shown.



The student used a metre rule to make measurements of the spring as the mass was increased.

The student plotted a graph of applied force F against the extension of the spring x.



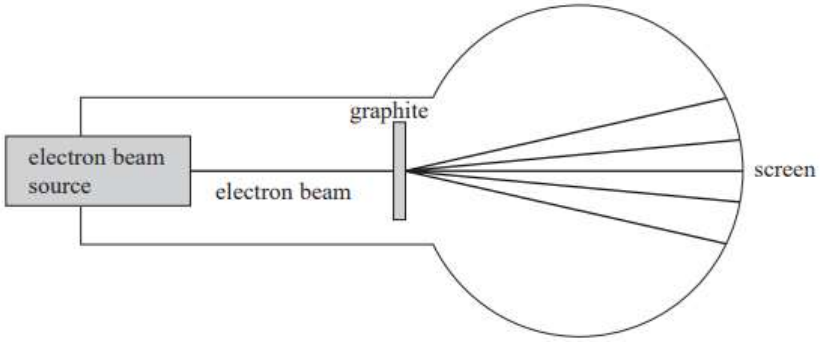
(a) Describe what the student should do to obtain the data to plot the force-extension graph.

1. Calculate Force = mg or use a Newtonmeter to measure weight
2. Measure initial length of spring and length with load, and subtract to give extension
3. align zero on ruler to bottom end of spring and read opposite bottom when loaded to measure extension
4. read scale opposite bottom of spring initially and again with load, and subtract to get extension
5. Use of a set square to ensure the ruler is vertical and to reduce parallax error when measuring length/extension or use of a pointer attached to the lower end of spring to reduce parallax error when measuring length/extension or ensure ruler and spring are at eye-level to reduce parallax
6. Uses a range of masses/forces to obtain multiple pairs of values

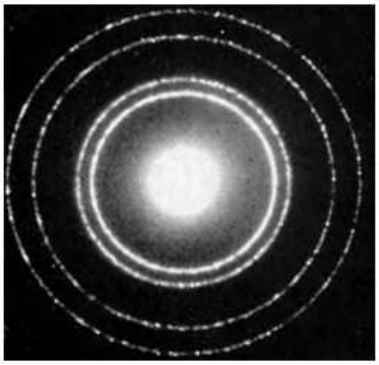
To determine the stiffness constant -

k = gradient Or k = ΔF/Δx
Gradient should be calculated using values from linear section of the graph

A student used an electron beam tube to accelerate electrons towards a thin slice of graphite as shown. The electrons passing through the graphite produced a diffraction pattern on the screen. This is similar to the effect seen when light passes through a diffraction grating.



The diffraction pattern seen on the curved screen is shown below.

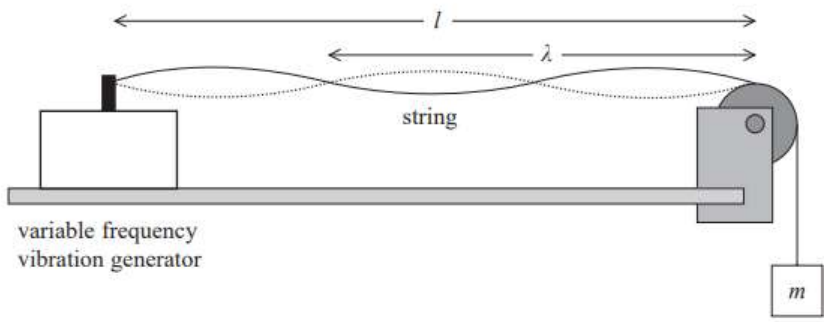


(a) Describe how the student can accurately determine the radius of the first bright ring of the diffraction pattern.

(4)

1. Use of Vernier calipers Or use of dividers/calipers to transfer the measurement to a ruler Or use of paper (tape) and marking points to be measured with a ruler Or use a flexible measuring tape
2. Measure diameter of (first) ring and divide by 2
3. Measure in multiple orientations and calculate the mean
4. Measure to the middle/brightest part of the ring Or refers to surface of the screen being curved (so diameter cannot be measured directly)

A student carried out an experiment to determine the mass per unit length μ of a string, using a standing wave. The standing wave produced is shown in the diagram.



The student recorded the following data.

Length of string l	1.25 m
Frequency f	105 Hz
Mass m	0.25 kg

(a) Calculate μ given the equation below.

$$\sqrt{\frac{mg}{\mu}} = f\lambda$$

Identify two significant sources of uncertainty in the student's measurements.

Frequency

1. Uncertainty in identifying when nodes form
2. Uncertainty in identifying maximum amplitude

Length

1. Parallax error when measuring length
2. Uncertainty in measuring length to top of pulley Or uncertainty in measuring length as string is not straight Mass
3. Zero error on mass balance

For each of these sources of uncertainty, describe an experimental technique the student could have used to obtain an accurate measurement.

Frequency

1. Repeat and calculate the mean frequency
2. Vary frequency from above and below resonance to find two values for the frequency when the standing wave forms

Length

1. Use a set square to reduce parallax error in length Or hold ruler in contact with the wire to reduce parallax error in length Or ensure ruler and string are at eye-level

Switch off vibrator Or ensure string is straight

Mass

1. Zero balance before each measurement
2. To remove systematic error Or idea that this error is not reduced by repeating

JAN 2018

You are to plan an experiment to determine the e.m.f. and internal resistance of a cell using a graphical method. The cell is labelled '1.5 V'.

(a) draw a circuit diagram of the apparatus to be used,

An appropriate circuit that includes cell (not battery), resistor, ammeter, voltmeter Means of varying current / p.d.

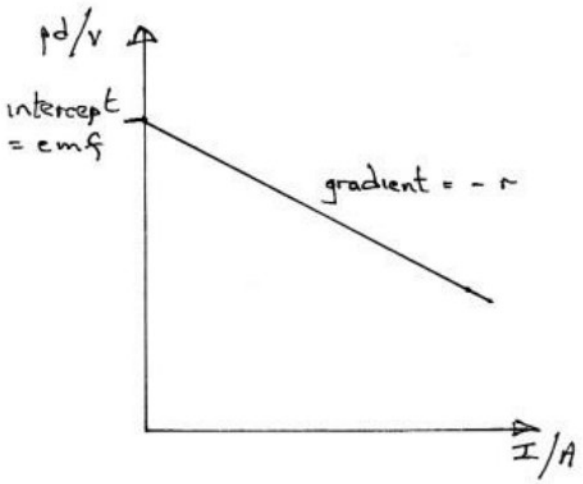
(b) state the quantities to be measured, Current and p.d.

(c) state which is the independent variable and which is the dependent variable, Current: independent p.d. dependent

(d) for one of the quantities listed in (b) explain your choice of measuring instrument, Current and ammeter Or p.d. and voltmeter (accept multimeter for either if scale mentioned) Reference to appropriate scale e.g. 2 V because cell labelled 1.5 V

(e) comment on whether repeat readings are appropriate in this case, Yes – so a mean can be calculated for each value Or to reduce random errors
No – because cell might run down Or better to take many readings (Ignore references to heating)

(f) explain how the data collected will be used, include a sketch of the expected graph, Plot graph of p.d. (y-axis) against current (x-axis) Sketch of graph (showing y-intercept and negative gradient) Identifies e.m.f. as intercept Identifies internal resistance as (−) gradient



(g) identify the main sources of uncertainty and/or systematic error, Difficulty of reading meters simultaneously Parallax error on analogue meter Fluctuating readings on meters Zero error on meter

(h) comment on safety low risk experiment as only 1.5 V

A student is to determine the viscosity η of a liquid using falling steel spheres and a graphical method.

The student has a measuring cylinder filled with the liquid and some steel spheres of different diameters.

The terminal velocity v of a sphere falling through the liquid is given by

$$v = 2\frac{r^2(\rho_s - \rho_l)g}{9\eta}$$

where r is the radius of the sphere, ρ_s is the density of steel and ρ_l is the density of the liquid. The values of both ρ_s and ρ_l are known.

Write a plan for this experiment.

You should:

(a) draw and label a diagram showing how the apparatus will be used,

1. Appropriate diagram including **two markers** on measuring cylinder or two light gates (first marker/light gate shown below surface of

liquid)

(b) list any additional measuring instruments required that are not shown in your diagram,

2. Metre rule [allow ruler] or tape, stopwatch or light gates, and micrometer or digital calliper

(c) list the quantities to be measured,

3. Diameter of sphere, time and distance between markers or time and distance between light gates

(d) for two quantities listed in (c) explain your choice of measuring instrument, For each Quantity and instrument Explanation, including indication of precision related to expected measurement

(e) state which is the independent variable and which is the dependent variable,

4. Diameter and time [allow radius for diameter and velocity for time] Independent and dependent variables correctly identified

(f) for one quantity comment on whether repeat readings are appropriate in this case, Quantity and comment Examples

5. Repeat diameter measurement at various orientations and averaged
6. Times should be repeated and averaged
7. Repeat identified measurement to eliminate anomalous values

(g) explain how the data collected will be used to determine the viscosity including a sketch of the expected graph,

8. Calculate velocity for each diameter/radius of sphere Or calculate r using d/2 for each sphere
9. Plot v against r^2 or v 1/2 against r Sketch of graph showing labelled axes and straight line through origin Uses equation to identify gradient consistent with their graph

(h) identify the main sources of uncertainty and/or systematic error, MAX 2

10. **Terminal velocity not reached before timing starts**.
11. Ball not dropped in centre of cylinder to eliminate edge effects.
12. **Time of fall short so reaction time is significant**
13. **Diameter of spheres small so large percentage uncertainty**
14. Zero error on micrometer or metre rule.
15. Parallax error in specified measurement

(i) comment on safety. Identification of risk with appropriate precaution Example Spills can cause slips, mop up A safe experiment, no precautions necessary

JUNE 2017

A student is asked to determine the resistance of a 12 V filament lamp at different potential differences. Plan an experiment to do this using a graphical method.

You should:

(a) draw and label a circuit diagram of the apparatus to be used, Circuit that would work Means of varying p.d.

(b) state the quantities to be measured, suggesting a suitable measuring instrument for each quantity

1. Current with ammeter
2. p.d. with voltmeter [Accept multimeters if setting identified]

(c) comment on whether repeat readings are appropriate in this case,

3. Repeat readings appropriate since mean can be found
4. Repeat readings appropriate to identify errors

(d) sketch the graph to be drawn and explain how the data collected will be used to determine the resistance at a given potential difference,

5. Either Plot graph of current against p.d. Or plot a graph of p.d. against current
6. Sketch of graph Use of R= V/I at a point to determine resistance Or Use of R= V/I to determine resistance
7. Plot graph of resistance against p.d.
8. Plot graph of p.d. against resistance

Sketch of graph

(e) identify the main sources of uncertainty and/or systematic error

9. Zero error on meter
10. Resistance inherent in circuit
11. Parallax errors with analogue meters

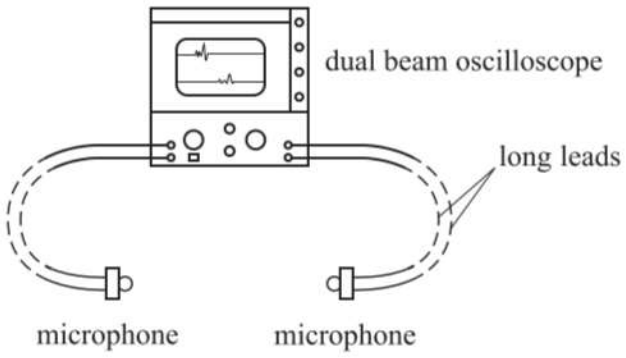
(f) comment on safety Sensible identification of risk with justification Example of answers

12. low risk experiment as only 12 V
13. avoid touching the hot lamp (which could cause burns)

JAN 2017

A student is asked to determine the speed of sound in air.

The apparatus to do this includes two microphones connected to an oscilloscope as shown.



The student will make a noise near one of the microphones. The oscilloscope can display the signals from both microphones as traces on the same screen. The student will observe the difference between the two stationary traces.

Write a plan for this experiment.

(a) outline the experimental procedure

1. Separate microphones
2. Measure distance between microphones
3. Measure difference in time between peaks on oscilloscope traces

(b) list any additional apparatus required not shown in the diagram

4. Metre rule Or tape measure
5. Means of making short sound

(c) state the quantities to be measured, identifying the independent and dependent variables

6. Distance and time
7. Correctly identifies distance as independent variable and time as dependent variable

(d) comment on whether repeat readings are appropriate,

8. (Yes) So a mean can be calculated
9. To reduce random errors (accept to reduce anomalous results)

(e) state how the data collected will be used to determine the speed of sound

10. Use of v= s/t

(f) **identify the main sources of uncertainty and/or systematic error and explain how you would minimise these,**

11. **Time interval is very small so maximise distance between microphones**
12. **Measuring difference in distance travelled by the sound to each microphone**

(g) comment on safety

13. Identifies this as a low risk experiment Or sound not too loud to avoid ear damage

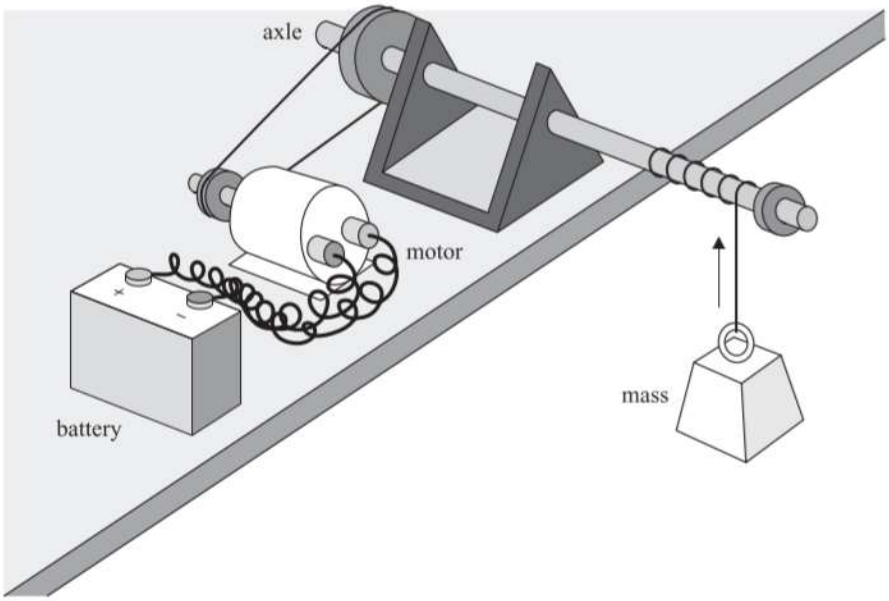
A student has been asked to determine the centre of gravity of a cricket bat like the one shown.

(a) Describe a simple method to determine the centre of gravity of the cricket bat.

(4)

1. Suspend the bat Or place bat on a knife edge
2. Move the bat until it hangs level Or until it balances
3. Mark/calculate the position of the centre of gravity
4. Repeat (with the bat in a different orientation)

7 A student is asked to determine the efficiency of a 9 V electric motor when it is used to lift a 1 kg mass at a steady speed. The diagram below shows the apparatus to be used.



Write a plan for an experiment to do this.

You should:

(a) state the quantities to be measured

1. potential difference, current, height and time 1 mark for 2 correct quantities from list, 2 marks for all four (no credit for mass /weight)

(b) for two of these quantities explain your choice of measuring instrument, max 2 per quantity, one mark for instrument and quantity and one mark for justification

2. e.g. metre rule for height 1 mm divisions and likely size of measurement e.g.Voltmeter for potential difference Precision 0.1 V for a 9V battery Or range of 0 -15 V for a 9V battery

(c) comment on whether repeat reading are appropriate in this case

3. Yes, repeat readings to obtain an **average to give more reliable results.** Or **No repeats because motor heats up** Or No **because battery p.d. reduces.**

(d) explain how the data collected will be used to calculate the efficiency of the motor

4. **Power** input =VI
5. **power** output = mgh/t use of efficiency = power output/power input Or Energy input =VIt Energy output = mgh

Use of efficiency = energy output/energy input
Or explicit graphical method e.g. Graph of h against t, find gradient, gradient x mg/VI

(e) identify the main sources of uncertainty and/or systematic error

7. parallax or random error in identified measurement
8. zero error in named instrument string slipping on winding mechanism **reaction time**

(f) appropriate comment on safety identification of risk and precaution e.g.

9. risk of mass falling on feet, wear shoes,
10. low risk as 9 V only,
11. risk of injury to eye if string breaks, wear goggles